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ARMSTRONG LABORATORY

LOGISTICS SUPPORT ANALYSIS OF ABSORPTIVE DYE-BASED LASER EYE PROTECTION (LEP) VISORS FOR ADVANCED AIRCREW VISION PROTECTION (AAVP) OUT-OF-BAND LASER (OBL)

Mark H. Awtry

TASC, Incorporated
55 Walkers Brook Drive
Reading, MA 01867

Dennis A. Maier

TASC, Incorporated
750 East Mulberry
Suite 302
San Antonio, TX 78212-3159

OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
Optical Radiation Division
8111 18th Street
Brooks Air Force Base, TX 78235-5215

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Robert M Cartledge

ROBERT M. CARTLEDGE, Lt Col, USAF, BSC
Chief, Optical Radiation Division

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Mark H. Awtry and Dennis A. Maier

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
TASC, Incorporated
750 East Mulberry
Suite 302
San Antonio, TX 78212

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This Logistics Support Analysis (LSA) was conducted as part of the Armstrong Laboratory, Advanced Aircrew Vision Protection/Out-of-Band Laser (AAVP/OBL) program which transitioned absorptive dye-based laser eye protection (LEP) pilot helmet visors to the Human Systems Center for acquisition. The use rates~~, annual demand~~ and support requirements for LEP visors were examined and projected based on the clear and neutral gray (sun) helmet visors currently in use. Aircrew strengths for different aircraft types, visor usage rates and different configurations of visors required to interface with the different helmets and oxygen masks are considered. Expected initial and recurring requirements for LEP visors are tabulated and discussed. The U.S. Air Force will require 7000 to 14000 laser/day visors and 3000 to 5000 laser/night visors annually. The maintenance and support of LEP visors can be accomplished for the most part with the personnel, training and equipment currently in place. The singular cause for removing helmet visors from service was found to be due to scratches. Improved scratch resistance coatings are recommended.

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FOREWORD

This report presents the results of a logistics support analysis conducted on the Advanced Aircrew Vision Protection/Out-of-Band Laser (AAVP/OBL), Advanced Technology Transition Development (ATTD) program. TASC wishes to acknowledge the contributions of the following individuals and organizations whose inputs provided the foundation of the analysis and which lend credence to the study findings.

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INTRODUCTION

This report summarizes the logistics support analysis (LSA) conducted under the Advanced Aircrew Vision Protection/Out-of-Band Laser (AAVP/OBL) project[1], an Armstrong Laboratory Advanced Technology Transition Development (ATTD) 6.3 program. The studies were carried out to address the logistics support requirements called for in the AAVP/OBL Technology Transition Plan in support of the Technology Transition Package (TTP) to be developed and provided to the Human Systems Center (HSC) at the conclusion of the ATTD program.

AAVP/OBL ATTD Program Overview

AAVP/OBL is intended to increase the options for aircrew eye protection against the harmful effects of battlefield lasers operating in the invisible spectra during daytime and nighttime operations. Aircrews are subject to a wide range of optical threats including laser defense weapons, directed radiators, target designators, optical munitions and tactical nuclear weapons encountered during military operations. Current laser eye protection (LEP) is approved for day use only and has limitations in terms of lighting compatibility. Day and night use LEP devices which provide protection at specific out-of-band wavelengths and transmits sufficient light to assure mission lighting compatibility are being transitioned.

AAVP/OBL technologies to be developed will demonstrate eye protection against specific laser threats in helmet visor format for day and night use. Specific laser protection technologies under consideration are based on absorptive filtering principals employing organic dyes either impregnated into or deposited onto a polycarbonate substrate. Absorptive dye technology is relatively mature, having been successfully employed against specific laser threats by all three of the military services. However, because only limited numbers of protective visors have been procured in the past, manufacturing processes are less mature as exhibited by low production yields and high unit costs ($200-$450). Moreover, application of this technology as protection against multiple laser threats which meet aircrew acceptance as both day and night LEP has yet to be proven.

The ATTD program will demonstrate through engineering evaluations, laboratory experiments, and man-rating assessments (ground and flight tests) the operational utility and performance benefits of AAVP/OBL eye protection. Test articles (FV-6, FV-6MR and FV-7[2]) that meet (or closely meet) desired physical and performance requirements of AAVP/OBL eye protection will be used in these assessments. In addition, manufacturing evaluations, physical testing and review of helmet visor specifications will be performed as part of the ATTD program. At the completion of ATTD, technical data will be

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[1] Project 2830, PE 63231F

[2] FV-6 (night), FV-6MR (minus ruby) and FV-7 (day) are Glendale Protective Technologies, Inc. test visors.

transitioned to the Human Systems Center Program Office (HSC/YA) for rapid engineering and manufacturing development (EMD) and production of LEP end articles.

The expected payoffs of developing the AAVP/OBL technology include enhanced eye protection against multiple laser threats, increased producibility (anticipated from proper specification of performance and testing requirements and improvements in manufacturing processes), improved supportability (due to fewer visor configurations and improved scratch resistance), and increased affordability (achieved through design, production and procurement initiatives).

AAVP/OBL Logistics Support Analysis Tasks

Influencing LEP design for supportability and minimizing modifications to existing equipment (e.g., cockpit and runway lighting, life support equipment, etc.) are key logistics support goals for the AAVP/OBL program. Beginning in concept development and continuing through EMD and production, these goals are achieved through an active LSA program, an integral part of system engineering. Within the context of the AAVP/OBL ATTD program, the focus of the LSA activities concentrate on the following tasks:

- Establish supportability factors by analyzing the intended application and use of AAVP/OBL visors
- Identify supportability - related issues through the analysis of comparative products and systems
- Determine supportability - related design considerations affecting AAVP/OBL products and the systems to which they interface

These tasks provide a solid foundation for product/equipment and support system design activities which occur in subsequent engineering and development phases.

USE FACTORS

Use factors define the unsafe parameters which drive AAVP/OBL visor design and supportability requirements. The key use factors are aircrew, equipment, and procurement factors. Aircrew factors relate to the intended aircrews of aircraft for which LEP has been deemed a necessity. Equipment factors relate to the complement of personal life support equipment to which visors interface. Procurement factors combine aircrew and equipment factors with failure factors to determine the necessary visor quantities to support initial and annual recurring requirements.

Aircrew Factors

Aircrew members are becoming increasingly subject to a wide range of optical threats, both friend and foe, during training, weapon test and evaluations, and during combat mission operations. The use of lasers for target designation, vehicle navigation, communication and as combat munitions has increased dramatically. Aircrews are particularly vulnerable to laser rangefinders during low-level operations and target designators, such as Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN), in battlefield situations and in training.

Tactical aircrews are the most vulnerable to laser effects at the present time. Therefore, LEP is initially slated for those aircrew members associated with tactical aircraft. Table 1 lists the candidate aircrews associated with weapons systems identified in the Technology Transition Plan.[3] In the future, AAVP/OBL may be extended to other USAF aircrews, other U.S. armed services, and NATO/allied forces.

Table 1. Candidate AAVP/OBL Aircrews

WEAPON SYSTEM AIRCREW
A-7
A-10
B-1
B-2
B-52
C-135
E/F-111
F-15
F-16
F-22
F-117

Equipment Factors

Visors are an integral part of an aircrew member's life support equipment, affording protection from windblast in the event of cockpit ejection during flight and from ballistic particles which may emanate from damage to the cockpit and/or canopy. Visors also are used to enhance visual acuity during day and night operations. The key interfacing life support equipment components are the member's helmet and oxygen mask assemblies.

[3] Technology Transition Plan, AAVP/OBL Protection, PE 6323F, Project 2830, 11 March 1993

The current Air Force flyer's helmet is the HGU-55/P (Figure 1). The helmet's basic shell is made of pressure-mold, laminated fiberglass cloth. Helmets are manufactured in three sizes. Visors are attached to the HGU-55/P helmet either via snap-fasteners (single or dual configurations) or side-actuated rotating lock/pivot mechanisms (dual configuration). Visors are interchangeable between helmet sizes, but only one may be donned at a time. Because visors are made of polycarbonate material and are highly susceptible to scratches (the primary failure mode), a moleskin lens cover is used to protect the surface of the visor when not in use on the helmet. Visors may also be removed and stored in a protective lens bag.

There are a number of different helmet visors in the Air Force inventory today. The two primary visors are the neutral gray and clear. The neutral gray visor, also referred to as the day visor or sun visor because of its use primarily as a day-only visor, affords ultraviolet (UV) and sunlight glare protection to the pilot in addition to standard visor protection. The clear visor is used primarily at night. Two other visors which are used by aircrew members are the amber visor also referred to as the "shooter's" visor or high-contrast visor and a 3-line laser visor (procured once prior to and in limited quantities during Desert Shield/Storm).

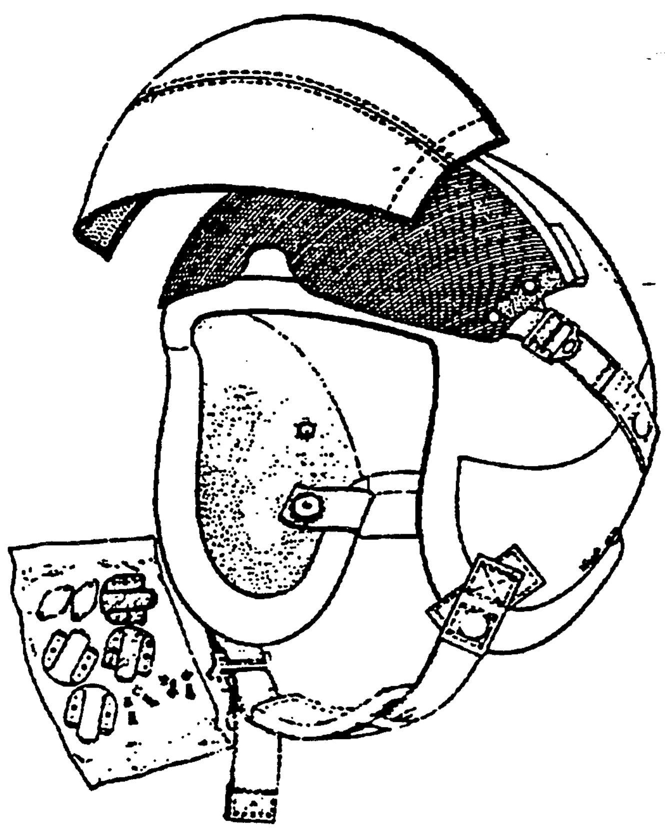

Figure 1. HGU-55/P flyer's helmet assembly (with protective lens cover).

Helmet visors are notched to conform to the contour of the top portion of the pilot's oxygen mask when the visor is donned (Figure 2). According to Air Force life support equipment specialists who manage visors there are three oxygen mask assemblies in use today: MBU-5/P, MBU-12/P and MBU-20/P. The MBU-5/P oxygen mask is an older mask assembly and is no longer procured; however, because they are still being used, logistics support is maintained.[4] The MBU-12/P is the standard flyer's oxygen mask. The Air Force has recently introduced a "pressure breathing for G" (PBG) oxygen mask assembly as part of the COMBAT EDGE (COMBined Advanced Technology, Enhanced Design "G" Ensemble) life support equipment upgrade for high-performance tactical aircraft (e.g., F-15 and F-16). Since oxygen masks are of different shape factors, visor notch size and shape vary as a function of oxygen mask type. Thus for each type of helmet visor, at least three different shape configurations exist. Table 2 lists current stock number and unit price data for the helmet visors in existence for the HGU-55/P helmet.

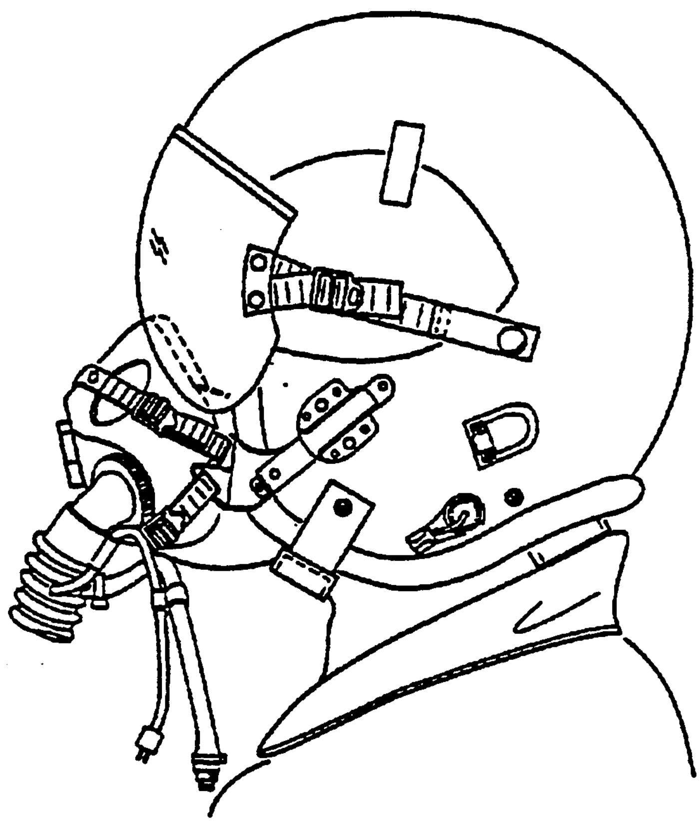

Figure 2. Donned HGU-55/P helmet, MGU-20/P oxygen mask and clear visor.

[4] According to life support equipment specialists, foreign military usage accounts for the majority of MBU-5/P oxygen masks in use today.

Table 2. HGU-55/P Helmet Visor Data

VISOR TYPE	MASK TYPE	NATIONAL STOCK NUMBER*	UNIT PRICE♦
Neutral Gray (Day)	MBU-5/P	8475-01-142-9184LS	$23.16
	MBU-12/P	8475-01-141-5917LS	$28.77
	MBU-20/P	8475-01-319-8961LS	$37.76
Clear (Night)	MBU-5/P	8475-01-141-5918LS	$35.19
	MBU-12/P	8475-01-143-2088LS	$21.77
	MBU-20/P	8475-01-319-8962LS	$37.76
Amber (Shooter)	MBU-5/P	8475-01-311-9630LS	$65.60
	MBU-12/P	8475-01-310-2225LS	$66.16
	MBU-20/P	Unassigned‡	—
Laser (3-line) (Barnes)	MBU-5/P	8475-01-295-4012LS	$487.28
	MBU-12/P	8475-01-295-4011LS	$468.08
	MBU-20/P	Not Available‡	—

* Source: HSC/YADTS (7/3)

♦Source: HSC/YADTS via D043A (7/93)

‡ Unassigned indicated that an item exists but has not been assigned a stock number; Not Available indicates that an item does not exist.

The Air Force is in the process of phasing-in the next generation lightweight flyer's helmet designated the HGU-53/P (Figure 3). The plan was to have the HGU-53/P become the standard issue flyer's helmet and replace the existing HGU-55/P helmets on an as-needed basis. The helmet is available in six sizes. Visors are secured to the helmet via visor arms attached to side-actuated rotation pivot/locking mechanisms.

HGU-53/P helmet visors are not interchangeable with the HGU-55/P visor assemblies. In addition, unlike the HGU-55/P helmet visor assemblies which fit all helmet sizes, the HGU-53/P helmet visor assemblies only fit every two helmet sizes. Thus three visor size versions are required to fit all helmet sizes. Moreover, since visors are notched according to oxygen mask configuration, over nine visor size/shape configurations for each of the four types of visors are needed to satisfy all possible life support equipment interface combinations. Table 3 summarizes the visor assemblies which exist for the HGU-53/P helmet and current oxygen mask assemblies.

Procurement Factors

Procurement factors relate to the number of laser helmet visors needed to support initial acquisition and annual recurring replacement requirements. Initial visor requirements are based on equipment usage and personnel factors; recurring requirements include failure factors as well.

Equipment Usage

The HGU-55/P flyer's helmet is the principal tactical aircrew member helmet used throughout the Air Force today. Originally, the helmet was scheduled to be phased-out and replaced by the new lightweight flyer's helmet, HGU-53/P. The initial replacement concept was to gradually phase-out the HGU-55/P via attrition, issuing the HGU-53/P helmet to new aircrew members and to existing members upon request on an as-needed basis. The planned phase-out/phase-in of the helmets was to occur over several years. Recently, however, the phase-in of the HGU-53/P has been delayed due to technical problems uncovered in production versions of the helmet. According to equipment specialists, there is considerable uncertainty as to when the HGU-53/P helmet will be phased-in. Thus, as least in the near-term, it appears that laser visors need only be procured for the HGU-55/P helmet and corresponding oxygen mask assemblies (MGU-12/P and -20/P).

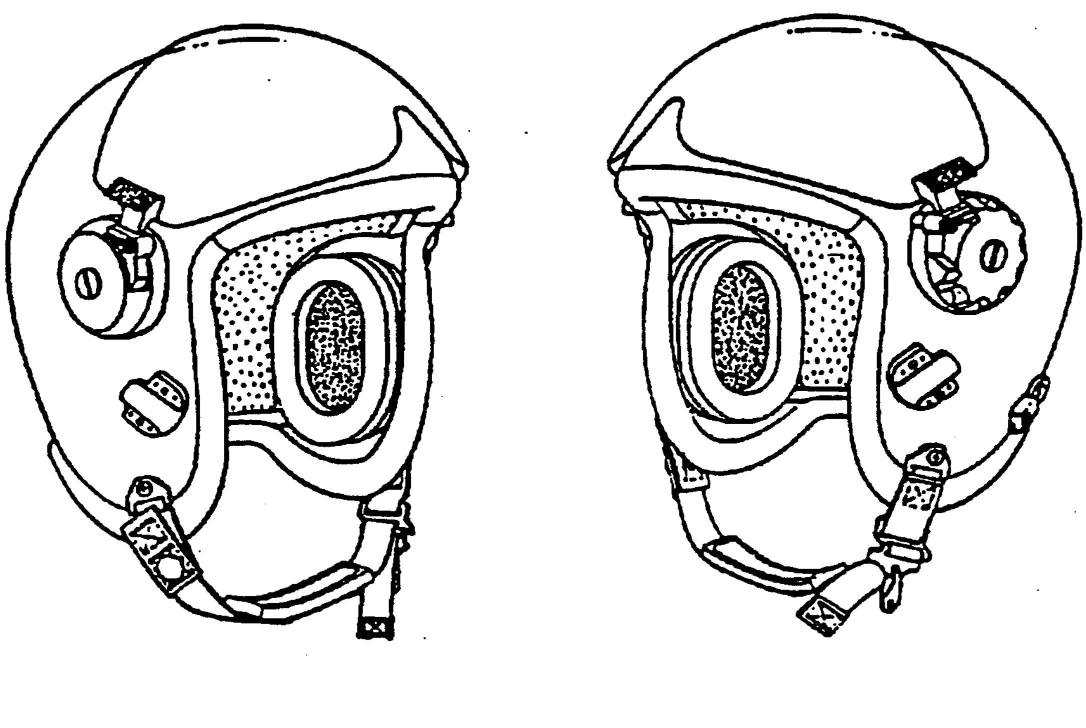

Figure 3. HGU-53/P flyer's helmet assembly.

Table 3. HGU-53/P Helmet Visor Data

VISOR TYPE	HELMET SIZE	MASK TYPE	NATIONAL STOCK NUMBER*	UNIT PRICE♦
Neutral Gray (Day)	Size 1/2	MBU-5/P	8475-02-353-2278	$61.03
		MBU-12/P	8475-02-340-1614	$45.04
		MBU-20/P	Unassigned‡	—
	Size 3/4	MBU-5/P	8475-01-352-4178	$61.03
		MBU-12/P	8475-01-335-3284	$45.04
		MBU-20/P	Unassigned	—
	Size 5/6	MBU-5/P	8475-01-352-4171	$61.03
		MBU-12/P	8475-01-335-3283	$45.04
		MBU-20/P	Unassigned	—
Clear (Night)	Size 1/2	MBU-5/P	8475-01-352-4180	$61.03
		MBU-12/P	8475-01-336-9225	$45.04
		MBU-20/P	Unassigned	—
	Size 3/4	MBU-5/P	8475-01-352-4181	$61.03
		MBU-12/P	8475-01-335-3282	$28.71
		MBU-20/P	Unassigned	—
	Size 5/6	MBU-5/P	8475-01-352-4182	$61.03
		MBU-12/P	8475-01-335-3285	$45.04
		MBU-20/P	Unassigned	—

* Source: HSC/YADTS (7/93)

♦ Source: HSC/YADTS via D043A (7/93)

‡ Unassigned indicated that an item exists but has not been assigned a stock number.
The amber (shooter's) visor and laser visor are not assigned.

Personnel Factors

The most influential factor on the procurement quantities of initial and annual recurring laser visors is installation basis (i.e., the number of aircrew members requiring laser protective eyewear). The quantity of aircrew members targeted for AAVP/OBL helmet visors is a function of a number of variables: mission profile, weapon system force structure, weapons system aircrew composition, and personnel attrition and accession rates. Increasingly, tactical missions are subject to laser threats, thus those missions/weapon systems involved with tactical operations are the principal candidates for LEP. Table 4 lists the candidate aircrews and corresponding personnel strengths (active and reserve forces). Aircrew strengths are based on Total Aircraft Inventory (TAI) data for combat and training missions[5] and aircrew composition programming factors.[6]

[5] Source: Automated Budget Interactive Data Environment System (ABIDES)

[6] Source: Air Force Instruction (AFI) 65503, *USAF Cost and Planning Factors*

As lasers continue to proliferate throughout the battlefield, it is likely that other aircrews, in addition to those involved in tactical operations, may require LEP (Table 5). Furthermore, other DoD and non-DoD components (e.g., NATO allies) may be interested in AAVP/OBL LEP as well. Table 6 summarized the potential installation basis for AAVP/OBL helmet visors.

The aircrew strengths shown above reflect FY92 force levels. Overall personnel levels have declined since FY92; by FY95 the Air Force will have suffered an eleven percent loss in total personnel strengths (based on programmed levels). Based on these trends, FY92 aircrew strengths represent a conservative, yet reasonable, estimate of the number of aircrew members targeted for LEP.

Table 4. Candidate AAVP/OBL Helmet Visor Aircrews[1]

MDS	NO. OF AIRCREW MEMBERS[2]
A-10A	300
A-7D/K	75
B-1B	375
B-2	150[3]
B-52G/H	1,025
C-135CE	100
E/F-11A/E/F/G	375
F-15A/B/C/D[4]	450
F-15E[4,5]	350
F-16A/B[4]	75
F-16C/D[4,5]	1,625
F-22	675[3]
Total	5,575

[1]Refer to Table 1
[2]Approximate (FY92 Levels)
[3]Quantities based on congressional levels (FY93)
[4]Combat EDGE aircraft
[5]LANTIRN equipped

Table 5. Other Potential Air Force
AAVP/OBL Helmet Aircrews[1]

MDS	NO. OF AIRCREW MEMBERS[2]
AC-130A/H	475
C-130B/E/H	2,850
F-117A	50
F-4E/G	125
HC-130L/N/P	325
RF-4C	250
WC-130H	125
WC-135B	50
Total	4,250

[1]Helmeted aircrews
[2]Approximate (FY92 Levels)

Table 6. Total Potential AAVP/OBL
Helmet Visor Installation Basis

AIRCREWS	NO. OF AIRCREW MEMBERS[2]
Candidate AF	4,750[1]
Other AF	4,250[2]
Other DoD	450[3]
Other Non-DoD	450[3]
Total	9,990

[1]From Table 4 less B-2 and F-22 (Future)
[2]From Table 5
[3]Five percent of Air Force Total

Failure Factors

The recurring demand for helmet visors is primarily based on failure modes, their frequencies and associated outcomes. Field experience on existing gray and clear visors indicates that the dominant failure mode for accounting for the majority of failures is excessive scratching in the frontal region of the visor. Since there is no repair of scratched visors, historical demand for visors is largely attributable to excessive scratching. Table 7 presents the demand history of existing gray and clear visors.

Table 7. HGU-55/P Helmet Visors-Demand History[1] (By Visor Type and Oxygen Mask)

VISOR TYPE	MASK TYPE	NATIONAL STOCK NUMBER	ANNUAL DEMAND
Neutral Gray (Day)	MBU-5/P	8475-01-142-9184	0
	MBU-12/P	8475-01-141-5917	13,737
	MBU-20/P	8475-01-319-8961	465
Clear (Night)	MBU-5/P	8475-01-141-5918	900
	MBU-12/P	8475-01-143-2088	1,716
	MBU-20/P	8474-01-319-8962	362

[1]Source: HSC/YADTS (7/93)

While the causes of scratching are, in general, well understood, the frequency at which scratching occurs is random and not well characterized. Furthermore, the determination of a failure varies, and aircrew members and life support specialists are given latitude in deciding the flight worthiness of a visor. Scratching will still be an issue with AAVP/OBL visors; however, scratch resistance should be higher than that of existing non-laser_visors because of improved protective coatings. Given the expected higher scratch resistant characteristics, the expected annual demand for laser visors should be at worst, no more than what the Air Force is currently experiencing with gray and clear visors. Therefore, the historical demand of the existing non-laser visors serves as a reasonable basis for projecting annual recurring AAVP/OBL helmet visor demands.

Procurement Requirements - Initial Acquisition

Table 8 presents the estimate of the total number of laser visors required to satisfy the initial outfitting of targeted aircrews. These numbers assume one visor of each type (laser/day and laser/night) for every aircrew member. A ten percent spares factor is used to account for additional initial inventory spares.

Table 8. AAVP/OBL HGU-55/P Helmet Visor Projections - Initial Quantities (By Aircrew Basis)

AIRCREW BASIS	INITIAL PROCUREMENT		INITIAL SPARES		TOTAL	
	LASER/ DAY	LASER/NIGHT	LASER/ DAY	LASER/NIGHT	LASER/ DAY	LASER/NIGHT
Candidate AF	4,750	4,750	475	475	5,335	5,335
Other AF	4,250	4,250	425	425	4,675	4,675
Other DoD	450	450	50	50	500	500
Other Non-DoD	450	450	50	50	500	500
Total	9,900	9,900	1,000	1,000	10,900	10,900

Table 9 presents a break-out of initial visor procurement quantities by aircrew basis and oxygen mask type. The distribution of total visor requirements among the different mask types is based on historical demand data shown in Table 7, tempered by judgment factors.[7] Initial laser/day and laser/night procurement quantities are summarized by mask type and aircrew basis (consolidated) in Table 10.

Table 9. AAVP/OBL HGU-55/P Helmet Visor Projections - Initial Quantities (By Aircrew Basis and Oxygen Mask Type)

AIRCREWS	MASK TYPE	LASER/DAY[1]	LASER/NIGHT[1]	NOTES
Candidate AF	MBU-5/P	250	250	5% of total
	MBU-12/P	3,800	3,800	Residual of MBU-5/P & MBU-20/P
	MBU-20/P	1,175	1,175	50% of Combat EDGE Aircrews (F-15/F-16)
Other AF	MBU-5/P	475	475	10% of total
	MBU-12/P	4,200	4,200	90% of total
	MBU-20/P	0	0	
Other DoD	MBU-5/P	25	25	5% of total
	MBU-12/P	400	400	80% of total
	MBU-20/P	75	75	15% of total
Other Non-DoD	MBU-5/P	250	250	50% of total
	MBU-12/P	250	250	50% of total
	MBU-20/P	0	0	

[1]Rounded to nearest 25th unit

The above quantities define initial procurement requirements less those for the HGU-53/P helmet. If the HGU-53/P helmet were to be phased-in, total purchase quantities for both laser/day and laser/night visors would remain roughly the same as projected above. However, the break-out between visor types, helmet sizes and oxygen mask configuration would vary based on the number of HGU-53/P and HGU-55/P helmets in existence.

[7] Judgment is used because historical visor demand data (D043A) reflects demands placed on the supply system and not actual item "failures." More precisely, supply demands represent projected purchase quantities based on a moving two-year average of buy requirements. While supply demands serve as a good proxy for item "Failures," it can be misleading in some instances. For example, if existing inventory levels are sufficient to sustain the out-year demand for items, no items are forecasted to be bought. However, this does not imply that the item is not expected to "fail" during the demand period. The demand for neutral gray visors for the MBU-5/P oxygen mask illustrates this point (zero demands projected). Historical D043A-based demand data may also be misleading for those items that are being phased-in as is the case of the Combat EDGE visors. In this situation, demand projections represent current *not* future asset positions. Thus demand quantities are likely to be understated. Therefore, historical demand data must be "adjusted" to reflect more realistically current conditions.

Table 10. AAVP/OBL HGU-55/P Helmet Visor Projections - Initial Quantities (Summary)

MASK TYPE	AIRCREWS	LASER/DAY	LASER/NIGHT
MBU-5/P	Candidate AF	250	250
	All Other	750	750
	Total	1,000	1,000
MBU-12/P	Candidate AF	3,800	3,800
	All Other	4,850	4,850
	Total	8,650	8,650
MBU-20/P	Candidate AF	1,175	1,175
	All Other	75	75
	Total	1,250	1,250

Procurement Requirements - Annual Recurring Replacement

Table 11 presents the estimate of the number of laser visors required to satisfy expected annual demand resulting from equipment "failures." The demand rates for day and night visors are based on the historical supply-based demand rates of existing gray and clear visors (refer to Table 12) which have been adjusted upwards to account for uncertainty.[8]

Table 11. AAVP/OBL HGU-55/P Helmet Visor Projections - Annual Recurring Quantities (By Aircrew Basis and Visor Type)

AIRCREWS	NO. OF AIRCREW MEMBERS	LASER/DAY		LASER/NIGHT	
		ANNUAL DEMAND RATE[1]	ANNUAL DEMAND	ANNUAL DEMAND RATE[1]	ANNUAL DEMAND
Candidate AF	4,750	1.5	7,125	0.5	2,375
Other AF	4,250	1.5	6,375	0.5	2,125
Other DoD	450	1.5	675	0.5	225
Other Non-DoD	450	1.5	675	0.5	225
Total	9,900		14,850		4,950

[1]Visors per aircrew member

[8] Field experience based on rough order estimates from life support specialists range from 1.25 to 1.75 visors per aircrew member per year for all visor types.

Table 12. HGU-55/P Helmet Visor Annual Demand Rates
(By Visor Type)

VISOR TYPE	ANNUAL DEMAND[1]	AIRCREW BASIS[2]	ANNUAL DEMAND RATE (PER AIRCREW MEMBER)
Day	14,202	9,900	1.43
Night	2,978	9,900	0.30

[1]Source: HSC/YADTS via D043A (7/93) - refer to Table 7
[2]All aircrews (Candidate, Other AF, Other DoD, and Other Non-DoD)

Table 13 presents a break-out of annual recurring visor procurement quantities by aircrew basis and oxygen mask type. The distribution of total visors requirements among the different mask types is based on the same allocation scheme used to project initial AAVP/OBL visor quantities. Annual recurring laser/day and laser/night procurement quantities are summarized by oxygen mask type and aircrew basis (consolidated) in Table 14.

Table 13. AAVP/OBL HGU-55/P Helmet Visor Projections -
Annual Recurring Quantities (By Aircrew Basis and Oxygen Mask Type)

AIRCREWS	OXYGEN MASK TYPE	LASER/DAY[1]	LASER/NIGHT[1]
Candidate AF	MBU-5/P	350	125
	MBU-12/P	5,175	1,725
	MBU-20/P	1,600	525
Other AF	MBU-5/P	625	200
	MBU-12/P	5,750	1,925
	MBU-20/P	0	0
Other DoD	MBU-5/P	35	10
	MBU-12/P	540	180
	MBU-20/P	100	35
Other Non-DoD	MBU-5/P	340	115
	MBU-12/P	340	115
	MBU-20/P	0	0

[1] Rounded to nearest 5th unit

Table 14. AAVP/OBL HGU-55/P Helmet Visor Projections - Annual Recurring Quantities (Summary)

MASK TYPE	AIRCREWS	LASER/DAY	LASER/NIGHT
MBU-5/P	Candidate AF	350	125
	All Other	1,000	325
	Total	1,350	450
MBU-12/P	Candidate AF	5,175	1,725
	All Other	6,630	2,220
	Total	11,805	3,945
MBU-20/P	Candidate AF	1,600	525
	All Other	100	35
	Total	1,700	560

SUPPORTABILITY ANALYSIS

The supportability characteristics of helmet-mounted LEP directly affect the effectiveness of logistics support. To the degree that supportability-related considerations are identified and quantified early in a product's lifecycle, the greater the potential for incorporating desirable supportability-related features into the design and fabrication of laser visors. The supportability aspects and experience of existing non-laser visors, which in many respects are similar to laser visors, as well as existing absorptive dye-based laser visors used elsewhere in DoD, form the basis of supportability-related considerations for the AAVP/OBL helmet visors.

This chapter summarizes the supportability assessment by logistic element (e.g., personnel skills and training). Specific findings and conclusions based on information obtained and analyzed as a result of discussions with logistics providers[9] and visor manufacturers[10] are presented. An overall summary is provided at the conclusion of this chapter.

[9] Air Force life support specialists (149th ANG, Kelly AFB, TX and 19th Air Force, Randolph AFB, TX), life support equipment specialists and items managers (San Antonio Air Logistics Center, Kelly AFB, TX), Navy equipment specialists and support technicians (Naval Air Warfare Center, Warminster, PA) and Army logistic manager (PM Soldier, Washington D.C.) and engineers (Individual Protection Directorate, Army Natick Lab, Natick, MA and Materials Directorate, Army Research Lab, Watertown, MA).

[10] Glendale Protective Technologies (and affiliates), AOtec, and Gentex Corporation.

Personnel Skills and Training

Findings

Personnel skills and training related to the inspection, maintenance, issuance, fitting and adjustment of existing, non-laser visors appear to be adequate based on comments offered by life-support specialists. Support largely relates to pre-flight and post-flight inspection and cleaning. Maintenance is generally limited to fixing broken or damaged straps and buckles. Maintenance also includes rubbing out scratches when possible using buffing compound and polish. Although the procedure for buffing out scratches is described in the Technical Orders (TOs) for helmet visors, this process is not used. It has been found to be ineffective in improving the scratched area.

With respect to existing absorptive dye-based laser visors, existing personnel skills and training relative to the care and maintenance of visors should be adequate according to the visor manufacturers. The original laser visors purchased from EDO Barnes for Desert Shield/Storm did require special cleaning and handling because of the incidence of inadvertent removal of protective coatings applied to the lens surface of the visor. This is not likely to be an issue for AAVP/OBL laser visors since in most applications, absorptive filters will be impregnated into the polycarbonate substrate.[11] Although polycarbonate visors will continue to be vulnerable to scratching, visor manufacturers assert that laser visors will have high abrasion resistance properties due to protective coatings.

Conclusions

Existing personnel skills and training appear to be adequate to support AAVP/OBL helmet visors. However, assuming unit cost goals are achieved ($100 per visor) on a large scale, the cost of laser visors will be 1.5 to 4 times that of existing non-laser helmet visors. Thus, proper care, handling and storage of laser visors will become more critical to mitigate the inadvertent damage caused by normal use and handling.

Special Tools and Test Equipment

Findings

No special tools or test equipment are needed to maintain existing non-laser helmet visors, according to life-support specialists. With respect to laser visors, one manufacturer indicated that a special test device may be needed to periodically verify

[11] The notable exception is AOtec's lamdba 3 dye which is currently applied as an external coating on one side of the lens surface.

optical densities (OD) at laser wavelengths. The specific need for scheduled OD testing stems from the following.

According to two of the visor manufacturers (AOtec and Gentex), certain organic dye formulations and applications are susceptible to solar radiation. Prolonged exposure to UV light causes a degradation in optical density. This effect is commonly referred to as solarization or weathering. The specific nature and characterization of solarization for particular dyes are reasonably well understood. The effects of solarization can be significant: empirical data in one case revealed a 30 percent degradation in OD after 200 hours of exposure.[12] Absorptive dye-based laser visors are also subject to high-energy exposure at laser wavelengths which can create a phenomenon known as bleaching. Bleaching, according to Gentex, relates to absorbing dye saturation, a condition whereby outgoing energy cannot be released as fast as incoming energy. Bleaching can also cause a degradation in OD. Depending on the intensity and duration of exposure coupled with the dye response characteristics, visors may recover from saturation (i.e., prior OD level is maintained); in other cases, permanent, irreversible damage may result (OD degraded).

The determination of whether a laser visor's OD has degraded to the point where it is no longer affording the minimum level of eye protection cannot be made by visual inspection.[13] To test for OD requires special test equipment (densitometer or equivalent), which is typically not found in the life-support squadron. AOtec indicated that they had developed a flashlight-sized device for a Navy customer that is used in the field to test for transmittance at selected wavelengths.

Conclusions

The requirement to verify OD to safeguard against the negative effects of solarization and bleaching appears to be well founded in order to assure LEP over time. OD degradation is generally not readily apparent, thus, special test equipment is needed to periodically test visors. The AAVP/OBL program office should continue working with visor manufacturers to find effective solutions for mitigating, identifying and controlling the effects of solarization and bleaching.

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[12] Specific OD degradation will vary according to exposure conditions (intensity, duration, etc.). The results indicated here do not portent to be typical of those to be experienced by the AAVP/OBL visors. They do, however, highlight the potential gravity of prolonged exposure to sunlight and the corresponding adverse impact that it has on OD, ultimately affecting LEP.

[13] According to manufacturers, solarization results in the discoloration of the visor. Strategies that exploit discolorization include using a color strip to compare that visor's "actual" (exposed) color with that of a "normal" visor and employing a small strip that covers part of the visor which can be removed to compare the exposed (actual) and non-exposed (normal) areas. Manufacturers have also compensated for expected OD degradation by increasing initial OD levels; while effective from a laser protection standpoint, luminous transmittance is adversely affected because resulting visors are darker, making them more difficult to see through.

Scheduled (Preventive) Maintenance

Findings

Scheduled maintenance requirements for existing clear and gray visors encompass pre- and post-flight (aircrew member usage) inspection and cleaning. Prior to use, visors are checked to ensure the lens is clean and free of debris and smudges which might impair vision. Debris and dirt are removed using a non-ammonia-based solution or mild detergent and a lint-free cloth. Loose or damaged attaching hardware (such as a frayed strap) are adjusted and replaced as needed.

According to Glendale, existing cleaning and inspection procedures and materials should be sufficient to care for laser visors. The manufacturer recommends avoiding alcohol-based solutions (may cause bleaching) and tissue cleaning paper (dry) to clean the visor (may cause scratching). No information was obtained on how to handle scratches. AOtec indicated the need for periodic testing of optical density to safeguard against any degradation that may result from solarization.

Conclusions

It appears that existing scheduled maintenance intervals, procedures and materials will need to be modified to accommodate the care of laser visors. Specifically, it appears that an additional maintenance requirement which addresses periodic testing of the visor's optical density is warranted. It also appears that alternate cleaning materials (solutions and cleaning cloths) are also needed. These additional requirements should be easily adopted within current helmet visor scheduled maintenance practices.

Unscheduled (Corrective) Maintenance

Findings

Field experience of existing clear and neutral gray visors indicates that the primary cause of visor "failures" is attributable to excessive scratching in the main viewing area. According to life support specialists, scratches are induced during normal use and in some instances through misuse and mishandling. Examples cited by life support specialists of how visors tend to get scratched include:

- By flanged nuts and adjustment strap buckles of the top visor coming in contact with the bottom visor in dual visor configuration when visors are donned and doffed

- By aircrew member eyeglasses coming in contact with the inside of visor as the visor is donned and doffed
- By pilots hitting their head on cockpit canopy when the protective lens cover is not being used
- By dirt, grit and other particles which are attracted to or deposited onto the visor

The incidence of scratching is often increased by aircrew member apathy towards the proper handling and storage of visors. The low cost (~$25) and abundance of visors are likely contributors to the prevailing attitudes that exist in the field.

Conclusions

Visors in general are particularly vulnerable to scratching. The incidence of excessive scratching resulting in a visor failure is directly linked to the visor's abrasion resistance properties and usage in the field. With respect to abrasion resistance, product requirements should be reviewed and requirements/design trade-offs conducted to more fully recognize the costs and benefits of improving abrasion resistance. Since aircrew member apathy will likely continue, it will be incumbent upon life-support specialists to articulate to users the benefits of proper use and handling of laser visors. Furthermore, the AAVP/OBL program office should continue to work with visor manufacturers, users (aircrew members) and support personnel (squadron life-support and depot-equipment specialists) in exploring ways to mitigate and control the incidence of scratching.

Packaging, Handling and Storage

Findings

Packaging requirements for storage and shipment of existing visors appear to be adequate according to life-support specialists. Visor manufacturers did not identify any special packaging requirements for laser visors.

Normal handling contributes to the incidence of scratching, the main cause of visor failures. Residues (grit, grime, jet fuel, etc.) that are picked up by the aircrew member are often transferred to the visor when it is donned and doffed. These particles can scratch and mar the lens surface which can obstruct an aircrew member's field of view or make it difficult to discern objects. Pile-fastened lens covers and separate storage bags are provided to protect visors when not in use either on the helmet or in the gear bag; it is at the aircrew member's discretion whether to employ these protective materials or not.

With respect to long-term storage, laser visors are assumed to have a shelf life. This assumption is likely to have emanated as a result of the effects of solarization and bleaching. According to the Navy, the shelf life of absorptive dye-based laser visors is

seven years. No basis was given as to why this interval has been adopted. This topic was explored with the chief chemist at one of the visor manufacturers. According to him, plastics in general do exhibit aging (breakdown) over time. Aging is accelerated by prolonged exposure to high temperature and high humidity. However, under typical operating and storage conditions, polycarbonate-based helmet visors should not degrade over their expected life. In his opinion, shelf life is not an issue.

Maintaining control with respect to distribution and storage may be a requirement for laser visors. The Navy currently regards laser visors as controlled items - visors are secured when not in use and destroyed at failure. Existing Air Force helmet visors are not considered to be controlled items.

Conclusions

Existing packaging of clear and neutral visors appears to be adequate to preserve the integrity of manufactured visors. No special packaging requirements have been identified for laser visors. Handling visors will continue to be problematic in that the environment in which visors are used is fraught with contaminants that are often attracted to or deposited on the lens surface, causing scratching. Shelf life is not a factor with existing visors and does not appear to be a factor for laser visors. However, the Air Force should continue to explore this further to determine the specific physical, chemical and operational factors that may affect the long-term stability of laser visors. Lastly, the Air Force should consider the benefits and costs associated with maintaining control of laser visors to safeguard against inadvertent disclosure of protection wavelengths and optical densities.

Supply and Procurement

Findings

Availability of existing clear and neutral gray visors appears to be adequate according to life-support specialists and data provided by depot-equipment specialists. Current procurement practices also appear to support field demand for existing visors.

An issue, however, is the number of visor configurations which must be maintained for each visor type (e.g., clear). As discussed previously, the visors which mate with the existing HGU-55/P helmet and current oxygen mask assemblies total three for each visor type (refer to Table 2). With respect to the HGU-53/P, the new lightweight flyer's helmet, the number of visor configurations required to mate with existing and planned oxygen masks triples to nine (refer to Table 3). However, with respect to HGU-53/P helmet visors, discussions with the helmet manufacturer (Gentex) revealed that the only difference

between visor sizes (one visor size fits every two helmet sizes) is the length of the attaching rotary pivot/locking mechanism arms.

Conclusions

Supply policies and practices appear to be adequate to support the introduction of laser visors. Procurement practices should focus on economic lot sizes since setup and other batch-oriented costs, according to visor manufacturers, are non-trivial and greatly affect the ultimate unit price paid for visors. The necessary visor configurations that must be stocked to support field demand for visors will affect required procurement quantities.

Stocking laser/day and laser/night visors for the HGU-55/P helmet currently will require only three shape configurations to mate with all existing oxygen mask assemblies. The introduction of the HGU-53/P helmet will quadruple the number of visor size/shape configurations to be maintained (three for the HGU-55/P, nine for the HGU-53/P). While this is not excessive, it does create the potential for supply stock-outs and increase logistics support costs. It appears the only difference between HGU-53/P helmet size visors is limited to the length of the attaching visor arms. Based on a cursory inspection, field attachment of the visor arms appears to be possible. If this is so, the number of lens assemblies that must be stocked to support local (i.e., squadron) requirements could be halved (three for each helmet type). This decreases the probability of stock-out and reduces overall logistics support costs. The Air Force should further investigate the practice of attaching visor arms in the field as a possible cost savings and availability improvement initiative.

SUMMARY AND RECOMMENDATIONS -

Summary

Existing helmet-mounted clear and neutral gray visors require minimal care and logistics support. The primary supportability-related drivers include lens surface susceptibility to scratching through normal use and handling, and the number of visor configurations to be stocked and maintained to support field demand. Aircrew member apathy in the care and handling of visors is also a factor, contributing to incidence of "failures."

The supportability-related drivers of existing visors are equally applicable to laser visors given the high degree of similarity between the types of devices. Supportability-related issues which are unique to laser visors include solarization and bleaching effects and the distribution and control of visor items. Solarization, a condition which can degrade the optical density of the visor (thus adversely affecting eye protection), creates a requirement for periodic testing of laser visors and special test equipment. Bleaching

which has a similar effect on visors as does solarization, further substantiates the need for OD integrity verification. Distribution and control of laser visors may be necessary to safeguard national security by preventing the unauthorized disclosure of laser wavelengths and optical densities.

Recommendations

As the AAVP/OBL program moves from technology demonstration into full-scale engineering and manufacturing development, the Air Force should establish a partnership with visor manufacturer(s), logistics providers and users to address supportability-related drivers and issues. Specifically, initial efforts should focus on approaches and strategies which:

- Mitigate the incidence and impact of scratching, the primary cause of existing helmet-mounted visor failures
- Mitigate or eliminate the effects of solarization and bleaching
- Reduce the number of visor configurations that must be maintained in order to service the field demand associated with HGU-55/P and HGU-53/P helmets and tactical oxygen masks
- Address distribution and control of laser visors to prevent unauthorized disclosure of laser wavelengths and optical densities